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Self-perception of tinnitus: study before and after adaptation of hearing aids

Autopercepção do zumbido: estudo pré e pós-adaptação de próteses auditivas

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ABSTRACT

Purpose: To verify the benefits of using hearing aids in self-perception of tinnitus in adults and elderly without previous experience of amplification. **Methods:** The study included individuals of both gender, with tinnitus complaint, accompanied in public hospital. The following tests and instruments were used to measure tinnitus and determine its discomfort: pitch and loudness, Visual Analogue Scale (VAS), minimum masking level, residual inhibition and Tinnitus Handicap Inventory (THI). The evaluations were performed in two stages: before the adaptation of the hearing aids and after one month of use of the devices. **Results:** Of the 20 participants, 60% were elderly. There was a difference in self-perception of tinnitus before and after hearing aid fitting, as measured by THI and VAS. Differences in psychoacoustic measures were also observed, with the exception of pitch, before and after amplification. In addition, there was a correlation between tinnitus time and age with final THI scores. **Conclusion:** The use of hearing aids was determined to reduce the annoyance caused by tinnitus, with changes in psycho-acoustic measures and impact on quality of life.

Keywords: Tinnitus; Hearing aids; Hearing; Hearing loss; Audiology

RESUMO

Objetivo: Verificar benefícios do uso de próteses auditivas na autopercepção do zumbido em adultos e idosos sem experiência prévia de amplificação. **Métodos:** O estudo incluiu indivíduos de ambos os sexos, com queixa de zumbido, acompanhados em hospital público. Aplicaram-se os seguintes exames e instrumentos para mensurar o zumbido e determinar o seu incômodo: pesquisa do *pitch* e *loudness*, Escala Visual Analógica (EVA), pesquisa do nível mínimo de mascaramento, inibição residual e *Tinnitus Handicap Inventory* (THI). As avaliações foram realizadas em duas etapas: antes da adaptação das próteses auditivas e após um mês de uso dos aparelhos. **Resultados:** Dos 20 indivíduos participantes, 60% eram idosos. Verificou-se diferença na autopercepção do zumbido pré e pós-protetização, medido pelas escalas THI e EVA. Também se observaram diferenças nas medidas psicoacústicas, com exceção do *pitch*, antes e após a amplificação. Além disso, houve correlação entre o tempo de zumbido e a idade com os escores finais do THI. **Conclusão:** O uso de próteses auditivas reduziu o incômodo provocado pelo zumbido, com alteração nas medidas psicoaústicas e no impacto na qualidade de vida.

Palavras-chave: Zumbido; Auxiliares de audição; Audição; Perda auditiva; Audiologia

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INTRODUCTION

Tinnitus is defined as the perception of a sound without any external sound source[1]. It may be the only or the main observed symptom of a wide range of underlying health issues that impair one's[2] health and well-being. Studies suggest that the most common fact related to tinnitus is hearing loss[1,2]. In cochlear damages, the cochlear nerve activity decreases because of the sound input reduction. Thus, neural activity increases at all levels of the central nervous system so as to compensate for the lack of stimulation[3].

Jastreboff's[4] neurophysiological model propose explanations for the different degrees of annoyance for individuals with tinnitus. The symptom would appear as a result of the dynamic interaction between some centers of the nervous system (including the auditory and non-auditory pathways) and the limbic system. This interaction would trigger negative emotional associations and, consequently, discomfort reactions to patients with clinically significant[5] tinnitus.

In addition to biopsychosocial aspects caused by the symptom, tinnitus is also a health issue which generates an expressive economic impact. Research points that health expenses spent with patients who have reported tinnitus complaints are high, because, in most cases, those patients seek medical care from several professionals. Furthermore, the authors highlight that health care cost is proportional to the severity of the symptom[6].

Nowadays, there are different treatments that have been proven as effective for all patients. The heterogeneity of tinnitus is a challenge to clinical research, for the symptom differ in many aspects, such as location, sound characteristics, underlying causes, comorbid conditions, among others[7].

Research has indicated that one of the therapeutic resources to reduce the discomfort reported by individual with tinnitus is the use of hearing aids, which amplify sounds in order to enable the stimulation of residual hearing, thus improving the hearing capacity of patient with hearing impairment[8]. That acoustic stimulation enhances the activity of the auditory cortex and might interfere in the central processing of tinnitus. It mitigates the brain's focus on the symptom, reducing the perception of it[9]. Besides reducing the level of discomfort and improving patients' quality of life, hearing aids may promote better general health to patients' emotional and auditory aspects[10], reducing stress commonly associated with hearing loss[11].

Before starting treatment, it is important to measure the psycho-acoustic characteristics of tinnitus to gather relevant diagnostic information. The measurement of tinnitus is performed through the acuphenometry exam, which assesses the individual's sensation of frequency (*pitch*) and intensity (l*oudness*). The main advantage of the exam is the possibility of monitoring the actual intensity of tinnitus, in addition to assisting in the topodiagnosis of hearing damage[12]. It is also recommended to apply questionnaires to assess the impact of tinnitus[13] on patients lives. Among other questionnaires, the *Tinnitus Handicap Inventory* (THI) stands out. It is simple to be applied and aims to determine the psycho-emotional and functional deficits caused by the symptom. Data collected through self-perception questionnaires and psycho-acoustic measures of tinnitus constitute different assessment approaches; however, they are complementary to measure tinnitus severity impact on patients' lives[14].

From this perspective, the importance of this study lies in the investigation of hearing aids usage in tinnitus cases associated with hearing loss. Not only does the study evaluate the impact of hearing aids use in the symptom, but it also includes patients' age and daily average usage time of the devices. To provide adequate guidance to users and achieve satisfactory results with amplification, a phonoaudiologist must be well-instructed about the factors that might mitigate patients' annoyance. Based on that, this study aims to verify the benefits of using hearing aids in self-perception of tinnitus, beyond changes in psycho-acoustic measures, in adults and elderly who have not had previous experience of amplification.

METHODS

The sample consists of adults and elderly with tinnitus (unilateral or bilateral) and hearing loss, diagnosed through otorhinolaryngological and audiological assessment. To be eligible for this study, participants had to meet the following criteria: to be at least 18 years old on the date of the first assessment; to take part in the two phases of the study; to be eligible for the use of hearing aids and receive hearing aids from Ministério da Saúde (Ministry of Health's hearing health program) at the center where this research was conducted; and to have noticed tinnitus that has lasted for at least three months. Patients who did not notice tinnitus by the time of the assessment, who have already used hearing aids, or who were unable to answer the questionnaires were excluded from the study.

From the definition of the eligibility criteria for the sample composition, all individuals with clinical indication of hearing aids fitting and tinnitus complaint were invited to participate in the study. Upon the acceptance of the patient, he/she was referred for specific evaluations for this study purpose. The evaluations were carried out in two phases: before the adaptation of the hearing aid and after one month of use. The evaluations were performed by a previously trained researcher.

Initially, the individuals who accepted to participate in the study signed the Informed Consent Form, agreeing to participate in the research voluntarily. Then they answered an interview protocol with personal, clinical, and occupational information.

In order to collect data and evaluate the degree of tinnitus discomfort, individuals were asked to answer THI survey, which was previously adapted to Brazilian population[13] and to Visual Analogue Scale (VAS). Additionally, individuals underwent psycho-acoustic assessments: acuphenometry (it was carried out to verify individuals' tinnitus *pitch* and *loudness*), minimum masking level (MML), and residual inhibition (RI).

The THI instrument is validated and translated into Brazilian Portuguese language[13]. It has 25 question with three levels of answers: yes (4 points), sometimes (2 points), and no (0 points). The scores are then added up to give a value out of 100, 0 (zero) to 100 points. Thus, scores from 0 to 16 indicate a light level of discomfort, from 18 to 36, mild, from 38 to 56, moderate, from 58 to 76, severe, from 78 to 100, catastrophic. To ensure patients' full understanding of the questions and completion of the survey, individual interviews were conducted.

The VAS is a scale in the style of a "thermometer" which patients use for rating the intensity of discomfort caused by tinnitus[15] on a scale from 0 to 10. It was considered as a discomfort reduction when, after treatment, there was a 2-point

score improvement on the VAS in comparison with the same individual's score before amplification.

Through acuphenometry it is possible to assess tinnitus *pitch* (frequency sensation) and *loudness* (intensity sensation). It was conducted as follows: to measure tinnitus pitch, pure tones or narrow band noises, depending on the type of tinnitus complaint related, were delivered from supra-aural headphones attached to the audiometer. Patients heard ten decibels above their auditory threshold (dBHL), which was measured by means of audiometry (250 Hz to 8000 Hz). The patient was instructed to raise his or her hand when realizing that the sound presented was similar to his or her tinnitus sensation. After pitch assessment, loudness sensation was investigated. The stimulus was presented at the frequency indicated by the patient in the pitch assessment, at an intensity of 10 dBHL below patient's auditory threshold. The intensity was increased in 1 dBNA step, and the patient was instructed to raise his or her hand when realizing that the sound presented was similar to his or her tinnitus sensation. This intensity was recorded and subtracted from the individual auditory threshold; therefore, quantifying the level of sensation (dBNs) in decibels. In cases of unilateral tinnitus, the assessment was carried out in the ipsilateral ear; in the case of bilateral tinnitus, each ear was investigated separately. Patients who have stated that none of the sounds was equivalent to his or her tinnitus, were deemed ineligible to compose the sample.

Through acuphenometry it is possible to assess tinnitus[12] *pitch* (frequency sensation) and *loudness* (intensity sensation). It was conducted as follows: to measure tinnitus pitch, pure tones or narrow band noises, depending on the type of tinnitus complaint related, were delivered from supra-aural headphones attached to the audiometer. Patients heard ten decibels above their auditory threshold (dBHL), which was measured by means of audiometry (250 Hz to 8000 Hz). The patient was instructed to raise his or her hand when realizing that the sound presented was similar to tinnitus sensation. After *pitch* assessment, *loudness* sensation was investigated. The stimulus was presented at the frequency indicated in the pitch assessment, at an intensity of 10 dBHL below patient's auditory threshold. The intensity was increased in 1 dBHL step, and the patient was instructed to raise his or her hand when realizing that the sound presented was similar to tinnitus sensation. This intensity was recorded and subtracted from the individual auditory threshold; therefore, it was possible to assess the level of sensation (dB SL) in decibels. In cases of unilateral tinnitus, the assessment was carried out in the ipsilateral ear; in the case of bilateral tinnitus, each ear was investigated separately. Patients who have stated that none of the sounds was equivalent to tinnitus sensation were ineligible to compose the sample.

The minimum masking threshold is the weakest level of noise necessary to mask an individual's tinnitus, and it aims to determine the effects of masking noises on symptom perception[12]. Initially, the patient's auditory threshold for narrow-band noises in the tinnitus frequency was measured (identified by means of *pitch* measurement); subsequently, the intensity was increased in 1 dBHL step, to the point that no tinnitus is reported. In cases of unilateral tinnitus, the sound was presented in the ipsilateral ear; in the case of bilateral tinnitus, the assessment was carried out in each ear separately[16].

As some patients may present temporarily tinnitus decreasing or dissipation after masking application, the residual inhibition research was included in this study. It can be used to assess treatment[16] results. The masking noise was delivered, for one minute, to the ipsilateral ear with tinnitus, 10 dBHL steps above the minimum masking level. Then the noise was interrupted and the patient was instructed to signal when he / she noticed tinnitus[16] again.

After this initial assessment, patients underwent hearing aids fitting. All patients were individually instructed about the proper use, care, and handling of the devices. The retroarticular model was delivered. The National Acoustics Labs, Non-Linear, version 1 (NAL-NL1), prescriptive method was followed to adjust electroacoustic characteristics of hearing aids. The place where the study was conducted follows that rule to perform hearing aids fitting.

After a minimum period of 30 days, patients went through the initial protocol again. At the appointment, all patients' doubts were solved and, if necessary, the devices were adjusted. To track the daily average usage time of the devices, the *data logging* tool was used.

It is important to highlight that, during the initial hearing aid adaptation process, patients were instructed only about the use of the devices. They were neither aware of possible hearing aids effects on masking tinnitus nor of the hearing-aid daily use tracking, which would be via *data logging*. In no case, the sound generator, which may be used to mask tinnitus, was activated.

With respect to participants of the sample, to determine the type and degree of hearing loss we followed the World Health Organization (WHO) grades classification, with calculation of the quadritone mean of the hearing thresholds (500 Hz to 4000 Hz).

The sample size was calculated through *WinPEPI* program (Programs for Epidemiologists for Windows), version 11.43, and based on a pilot study with ten patients. For a significance level of 5%, power of 90%, estimating a minimum size and a standard deviation between the two assessments (pre and post), a total minimum of 17 patients was found.

After data collection, we performed the analysis, quantitative variables were described as mean and standard deviation, or median, and interquartile range. Categorical variables were described by means of absolute and relative frequencies. To compare pre and post hearing aids medians, the Wilcoxon test was used. Associations between variables were evaluated using Spearman's correlation coefficient. The significance level adopted was 5% ($p \leq 0.05$) and the analysis was performed using the SPSS program, version 21.0.

This study was approved by the Comitê de Ética em Pesquisa do Hospital de Clínicas de Porto Alegre (Research Ethics Committee of the Hospital de Clínicas of Porto Alegre), under the number 66950417.2.0000.5327 All participants were guaranteed the confidentiality, anonymity, and the possibility of no longer be a subject of the study.

RESULTS

The sample has a total of 20 patients with chronic tinnitus, most of them are elderly (60%). In the beginning of the study, 41 patients were evaluated as possibly eligible for the sample. However, 21 patients were excluded; 13 did not report the discomfort as a symptom, 2 reported that were not wearing the hearing aids. During the 30-day period between the assessments, 2 individuals reported previous experience with amplification, 2 patients did not present for data collection, 1 could not be part of the study because of health problems, and 1 could not

fill in the THI questionnaire. Therefore, after all the exclusions, it was found the sample number determined by calculation.

There was a predominance of unilateral tinnitus, wheezing type and with gradual onset (Table 1).

In relation to hearing, sensorineural hearing loss and mild degree were the most prevalent. The daily average usage time of the devices was 4 hours a day. There was no difference between the ears about the average of hearing thresholds ($p = 0.457$), the degree ($p = 0.531$), and the type of hearing loss ($p = 0.717$). Considering the time of total use of the hearing aids ($p = 0.283$) and the daily average hearing aids usage time ($p = 0.370$), there was also no difference between the ears (Table 2).

Comparing the tinnitus assessments, made before and after fitting, there was a significant reduction in discomfort, measured by the THI and VAS. Differences in psycho-acoustic measurements were also found, except for pitch, before and after amplification (Table 3). There was a classification improvement of tinnitus severity degree, according to THI, after treatment (Figure 1).

The analysis of the result in the THI and the daily average hearing aids usage time showed that the longer the time of usage, the lower the THI score (Table 4). Besides, tinnitus duration and age also influenced the final THI scores. Therefore, the longer the tinnitus duration and the greater the patient's age, the less likely is the reduction in tinnitus annoyance after the adaptation of the hearing devices (Table 5). There was no relation between gender and tinnitus discomfort ($p > 0.10$).

Table 1. Sample specification

Variable	n=20
Age (years) – average ± SD	63.7 ± 10.5
Gender – n(%)	
Female	10 (50.0)
Male	10 (50.0)
Level of education – average ± SD	6.3 ± 3.2
Tinnitus time (year) – median (P25-P75)	6.5 (5-15)
Tinnitus – n(%)	
Unilateral	11 (55.0)
Bilateral	9 (45.0)
Ear – n(%)	
Right	3 (15.0)
Left	8 (40.0)
Both ears	8 (40.0)
Head	1 (5.0)
Worse bilateral side – n(%)	
RE	4 (44.4)
LE	3 (33.3)
Equal	2 (22.2)
Onset – n(%)	
Sudden	2 (10.0)
Gradual	12 (60.0)
After exposure to noise	2 (10.0)
Other	4 (20.0)
Worsening – n(%)	
In the morning	1 (5.0)
At night	2 (10.0)
Silence	6 (30.0)
Noise	1 (5.0)
Others	3 (15.0)
Stress	5 (25.0)
No worsening	2 (10.0)
Loss – n(%)	
Bilateral	19 (95.0)
Unilateral	1 (5.0)

Subtitle: SD = standard deviation; P = percentile; % = percentage; n = absolute value; RE = right ear; LE = left ear

DISCUSSION

In the sample, the percentage of elderly people was higher than that of adults, the same scenario was found in another study[17]. Research point to a significant increasing in the prevalence of tinnitus and its relation to age[15,18]. It is known that, with each additional year of age, the risk of tinnitus symptom[18] increases by 3%.

In this study, most patients had unilateral tinnitus, bilateral hearing loss, sensorineural type, and were fitted with hearing aids in both ears. A previous study indicate that clinical results are better in patients who have received bilateral amplification compared with those who have received unilateral acoustic stimulation[19].

As for the degree of loss, mild and moderate loss were the most prevalent types, those findings corroborate with other studies[10,20]. Hearing loss is the main risk factor for tinnitus. According to literature approximately 85% of individuals with tinnitus have some degree of hearing loss[1]. Consequently, damage or degeneration of the inner ear and the vestibulocochlear nerve cause neural activity spontaneous to increase, and this growth contributes to the generation and perception of the symptom[20-22].

Tinnitus is known to result in a range of responses from the autonomic nervous system that triggers feelings of anxiety, frustration, and stress. The results of this study show that after using the hearing aids, patients' self-perception of tinnitus have dropped. Thus, with acoustic stimulation, the patient changes his/her focus to another auditory stimulation that is not corresponding to tinnitus sound. Studies suggest improvement in emotional aspects after the use of hearing aids[9,10]. Amplification alters functional connections, especially between the auditory

Table 2. Ear specification

Variable	n=29
Tinnitus sensation – n(%)	
Continuous	24 (82.8)
Pulsatile	2 (6.9)
Intermittent	3 (10.3)
Tinnitus type – n(%)	
Whistling	9 (31.0)
Wheezing	18 (62.1)
Other	2 (6.9)
Quadritone mean– average ± SD	49.3 ± 16.0
Loss type – n(%)	
Sensorineural	18 (62.1)
Mixed	11 (37.9)
Degree – n(%)	
Mild (26-40)	11 (37.9)
Moderate (41-60)	10 (34.5)
Severe (61-80)	8 (27.6)
Data logging total - median (P25-P75)	159 (64.5-322.5)
Data logging average/day – median (P25-P75)	4 (2-11)

Subtitle: SD = standard deviation; P = percentile; n = absolute value; % = percentage

Table 3. Psychoacoustic measures and discomfort evaluation of tinnitus through *Tinnitus Handicap Inventory* and Visual Analogue Scale pre and post hearing aids fitting.

Variable	Pre	Post	p value
	Median (P25-P75)	Median (P25-P75)	
Loudness			
Total	10 (5.5-14.5)	4 (-1-10.5)	0.001*
RE	10 (6.25-16)	2 (-1-14.75)	0.026*
LE	10 (5-12.5)	5 (.50-10)	0.025*
Pitch			
Total	3000 (1500-8000)	3000 (-1-6000)	0.055
RE	3500 (1125-7500)	1750 (-1-5500)	0.028*
LE	3000 (1500-8000)	3000 (749-7000)	0.484
MML			
Total	15 (7-21.5)	6 (-1-11)	<0.001*
RE	15.50 (6.25-20.75)	4 (-1-9.75)	0.021*
LE	15 (8-22)	6 (2-15.50)	0.003*
RI			
Total	18 (3-36.5)	38 (5-no tinnitus reported)	0.010*
RE	22 (3.25-68.50)	34 (5-no tinnitus reported)	0.248
LE	6 (2.50-35.50)	38 (4.50-300.50)	0.016*
THI			
Total	54 (40-72)	22 (10-30)	<0.001*
RE	49 (40-64)	21 (10-29.50)	0.002*
LE	64 (44-75)	22 (9-34)	<0.001*
VAS			
Total	9 (8-10)	7 (4-8)	<0.001*
RE	9 (8-9.75)	6 (4-8)	0.003*
LE	9 (8-10)	7 (4-8)	0.001*

*Statistically significant association 5% (p<0.05)
Subtitle: P = percentile; MML = minimum masking level; RI = residual inhibition; THI = *Tinnitus Handicap Inventory*; VAS = Visual Analogue Scale; RE = right ear; LE = left ear; -1 = patient did not report tinnitus at the assessment appointment after hearing aids fitting

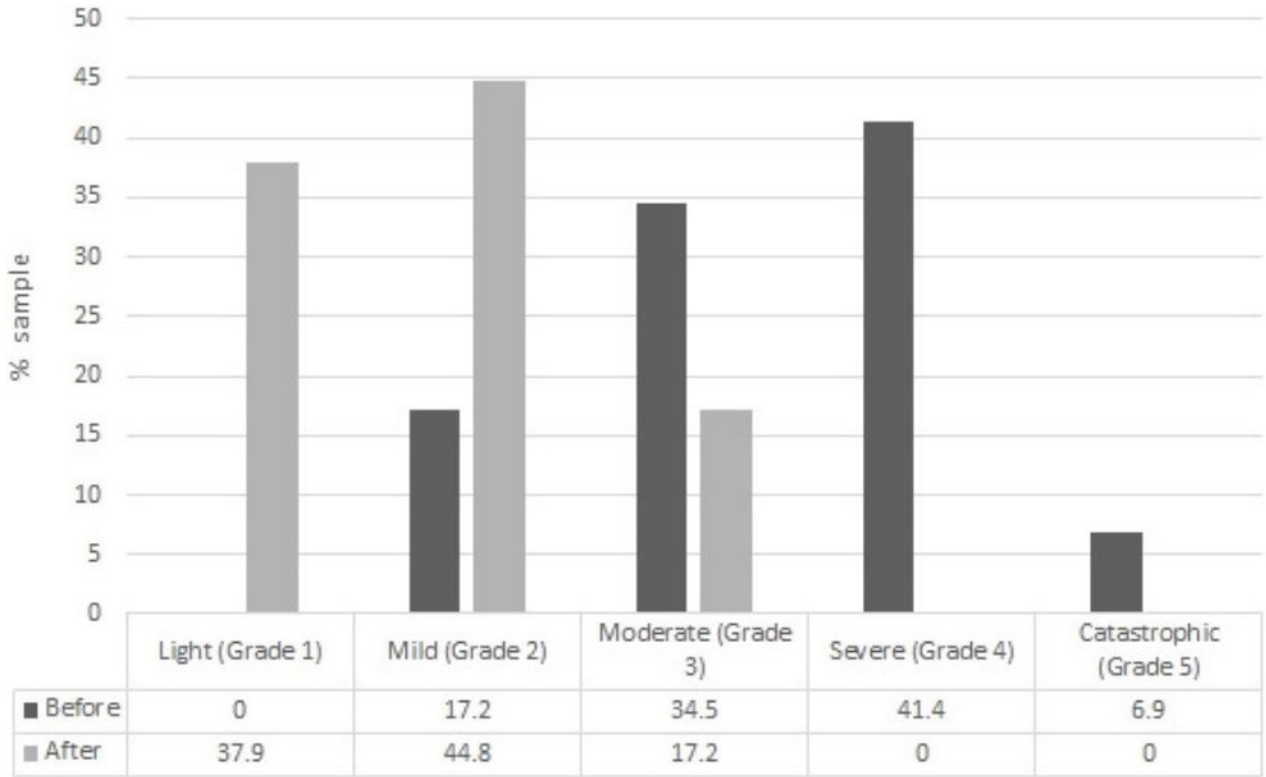

Figure 1. *Tinnitus Handicap Inventory* classification of pre and post hearing aids fitting (p<0.001)
Subtitle: % = percentage

cortex and the limbic system, thus modifying the activity pattern of the central nervous system, which can make tinnitus less impactful for the patient.

Changes in psycho-acoustic characteristics were found after amplification, which was unexpected considering that previous studies have stated that these characteristics of tinnitus do not influence the discomfort caused[22] by the symptom. There was a significant reduction in the sensation of tinnitus intensity between the assessments, in both ears. We emphasize that seven patients reported not having had tinnitus at the final evaluation. The results differ from a previous study[21] that found no differences in *loudness* after three months of hearing aid use. Although other studies have pointed to a reduction in tinnitus intensity levels after one month of hearing aid use[17,23].

There was a higher prevalence of tinnitus frequencies around 3000 Hz. As this value is within the frequency range of amplification of hearing aids, it could explain the positive prognosis toward the reduction of discomfort associated with the symptom[17,24].

To MML, the average of the first assessment was 15 dB SL. After treatment, patients reported considerable changes in MML. The MML reflects the ease with which tinnitus can be masked by environmental sounds. Based on literature, when the patient notices a reduction in tinnitus discomfort, the intensity of the MML decreases[22]. A study shows a positive correlation between MML and reduction of the discomfort caused by tinnitus, which is measured through THI and VAS[22].

At the second assessment, the RI scores had an overall increase. The average time a patient went without noticing tinnitus at the first assessment was 18 seconds, whereas it was 38 seconds at the second assessment, after applying the masking. Residual inhibition usually lasts only a few seconds or minutes, but it may persist for a longer time[25] occasionally.

The VAS results were not the same, the pre-adaptation scores differed from the post-adaptation ones reported by patients. VAS is widely used by professionals because it is a quick and simple tool to assess tinnitus degree. Also, patients[14] can understand and answer it effortlessly. In a previous study[26], 1440 cases of patients with tinnitus who used hearing aids were analyzed. Considering VAS results, there was a substantial improvement in the perception of tinnitus in 68% of the cases.

The THI questionnaire also shows a reduction in the complaint of tinnitus discomfort. At the first assessment, most patients rated the discomfort as intense; however, after using a hearing aid, patients reported mitigation of the symptom. The values found in the questionnaire are similar to those pointed out in other studies, after a month of amplification[17,19]. There was a direct relation between the questionnaire score and the time of use of the devices. That is, the longer the patient uses the hearing aid daily, the more the complaint of discomfort is reduced, which makes evident the possible benefits of such technology to patients with tinnitus.

A study using magnetoencephalography investigated the changes in neural network activity that occur in patients with long-term tinnitus. The analysis showed that, compared with the short-term tinnitus group, in the group that had the

Table 4. Relation between hearing aids use and tinnitus discomfort after hearing aids fitting

Variable	*Data logging* average/daily	p value
	Spearman's correlation coefficient (r_s)	
Loudness		
Total	-0.237	0.215
RE	0.117	0.718
LE	-0.419	0.094
Pitch		
Total	-0.118	0.542
RE	0.365	0.243
LE	-0.391	0.121
MML		
Total	-0.292	0.124
RE	-0.044	0.891
LE	-0.312	0.222
RI		
Total	0.185	0.336
RE	0.065	0.840
LE	0.249	0.335
THI		
Total	-0.442	0.016*
RE	-0.439	0.153
LE	-0.465	0.060
VAS		
Total	-0.082	0.671
RE	0.098	0.763
LE	-0.182	0.486

*Statistically significant association 5% (p<0.05)
Subtitle: MML = minimum masking level; RI = residual inhibition; THI =Tinnitus Handicap Inventory; VAS = Visual Analogue Scale; RE = right ear; LE = left ear

Table 5. Relation between tinnitus time and age with performance differences between *Tinnitus Handicap Inventory* and Visual Analogue Scale assessments before and after hearing aids fitting

Variable	Tinnitus time	p value	Age	P value
	Spearman's correlation coefficient (r_s)		Spearman's correlation coefficient (r_s)	
THI				
Pre	-0.287	0.131	-0.581	0.001*
Post	0.212	0.269	-0.265	0.165
Difference (Post-Pre)	0.384	0.040*	0.426	0.021*
VAS				
Pre	-0.239	0.213	-0.022	0.910
Post	0.035	0.855	-0.239	0.212
Difference (Post-Pre)	0.111	0.566	-0.364	0.052

*Statistically significant association 5% (p<0.05)
Subtitle: THI = *Tinnitus Handicap Inventory*; VAS = Visual Analog Scale

symptom for more than four years, neural activity was widely distributed throughout the cortex, and the functional connections between the non-auditory areas increased. The authors state that neural architecture can change with increasing tinnitus time[27]. The duration of tinnitus also has a positive correlation with the effective increase in connections between the right hippocampus and the left auditory cortex[28]. This explains our findings, as patients with long-term tinnitus had less reduction of discomfort after being using amplification devices. The data show the importance of early use devices for a positive prognosis in patients with tinnitus and hearing loss, considering that the duration of tinnitus and its discomfort are linked to the activation of brain areas involved in attention, emotion, and memory processes.

There was a connection between age and the reduction of THI scores after the fitting of hearing aids. One assumption for this finding is that older patients may have had the symptom for a longer time, as hearing loss worsens with age, which in turn increases the risk of developing tinnitus. In addition, neuroplasticity mechanisms are altered with aging, and their efficiency decreases throughout human life[27]. Changes in the neural structure play a crucial role in the generation of tinnitus and its discomfort[29]. Thus, with advancing age, the patient may become less sensitive to the effects of amplification.

CONCLUSION

There was a reduction in the discomfort caused by tinnitus, as well as changes in the psycho-acoustic measures after the sound amplification. Therefore, we believe that the use of hearing aids has brought benefits for the patients of this study. Tinnitus duration and advanced age impacted the self-perception of the symptom negatively after hearing rehabilitation.

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